ASA grade and tip-apex distance are predictive of post-operative problems after fixation of trochanteric hip fractures with sliding hip screw or intramedullary devices.

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Abstract

Introduction

Hip fractures are common and disabling injuries, affecting mainly older adults. Due to the morbidity associated with non-operative management, most are managed surgically. Trochanteric fractures are generally fixed with a sliding hip screw or an intramedullary nail. Data is available in the National Hip Fracture Database to quantify early failures of fixation, amongst other major complications, but late or less overt complications may not be recorded. This study sought to quantify and describe problems arising after fixation and from this information identify predictors of such problems.

Methods

Patients with a trochanteric fracture were identified from the NHFD over a three-year period from three different sites. From this cohort, any patients with further related episodes of care were identified and reasons recorded. These patients were then age- and sex-matched with those with no identifiable related episodes of care. Data was collected on Arbeitsgemeinschaft für Osteosynthesefragen classification, tip-apex distance, American Society of Anesthesiologists grade, Abbreviated Mental Test Score and pre-injury mobility levels. A binomial logistic regression model used to identify predictors of problems.

Results

A total of 4010 patients were entered in the NHFD across three sites between January 2013 and December 2015. Of these, 1260 had sustained trochanteric fractures and 57 (4.5%) subsequently experienced problems that led to them re-presenting to a hip surgeon. The most common problem was failure of fixation, occurring in 22 patients (1.7%). The binomial logistic regression model explained 47.6% of the variance in incidence of problems. Two variables, ASA grade and tip-apex distance were predictive of problems.

Discussion

The incidence of re-presentation with problems following fixation of trochanteric hip fractures is in the region of 5%. A failure rate of less than 2% was seen, in keeping with

existing data. Crucially, whether an intramedullary nail or sliding hip screw was used was not predictive and patients with both classes of device experienced problems. We have shown that fixation of hip fractures continues to yield imperfect results, and that the health state of the patient and adherence to basic surgical principles may prove the most important factors driving a good outcome.

Introduction

Over 66,000 patients sustained a hip fracture in England, Wales or Northern Ireland in 2018 (Royal College of Physicians 2019) with an estimated annual cost to the British economy greater than £1 billion for hospital treatment and rehabilitation (Leal et al., 2015). It is predicted that the incidence of hip fracture will rise globally due to increasing life expectancy (Hernlund et al. 2013). The effect of these injuries is profound; even after a sustained programme of quality improvement, mortality at 30 days post-injury remains 6.1% (Royal College of Physicians 2019). Traditionally, the analysis of outcomes of hip fracture has focused on binary outcomes such as mortality or healthcare system factors such as length of stay and cost. The consideration of the impact on the patient's function and quality of life allows increased understanding and targeting of interventions (Parsons et al., 2014). Patients have been shown never to recover their previous function after hip fracture and, for a number of months post-injury, rate their health state as worse than being dead (Griffin et al., 2015). Although 67% of patients are reported to have returned to their original residence, only 10% of patients featured in the 2017 National Hip Fracture Database report described themselves as able to walk without an aid at four months post-injury (Royal College of Physicians, 2017).

Hip fractures are, with few exceptions, treated operatively. Intracapsular fractures, unless undisplaced, are presumed to have an inherently impaired blood supply and so all displaced fractures are managed with some form of joint replacement, whether hemiarthroplasty in lower-function patients or total hip arthroplasty in more active and high-demand ones. The management of trochanteric fractures is based on fixation, with the sliding hip screw (SHS) recommended for stable (AO/OTA 31A1/A2) fractures in preference to intramedullary or cephalomedullary nails (IMN) (National Clinical Guideline Centre 2017). The sliding hip screw offers fixation off the anatomical axis of the femur, with a large compression screw passing within and in line with the femoral neck, permitting both initial compression of the fracture and subsequent collapse and hence compression under physiological load. Intramedullary nails, by contrast, provide fixation on the axis of the femur, protection against excessive femoral medialization where the integrity of the lateral wall of the greater trochanter is in question and offer the ability to lock the femoral head compression screw within the nail itself, thereby controlling the degree of collapse and hence femoral neck shortening. One of the most recent randomized controlled trials found, however, that this shortening was measurable radiologically but had no functional impact on patients (Reindl et al. 2015). This fits with a recent meta-analysis of 6,911 patients participating in 43 trials showing no clinically relevant differences between the SHS (Yu et al. 2015).

As usage of intramedullary devices has grown alongside surgeon confidence and competence, there is now a concern that they may in fact be over-used (Page et al., 2016). In the latest versions of the NICE guidance for hip fracture, the indication for use of an IMN remains an unstable intertrochanteric or a subtrochanteric (31A3 or 32x) fracture (OTA Classification, Outcomes and Database Committee 2018), and an increasing level of surveillance of the use of IMNs in 31A2 fractures has been introduced within the National Hip Fracture Database (Royal College of Physicians, 2017). In addition to the year-on year trends, there is also a wide variability between centres in the proportion of trochanteric fractures fixed by SHS. In the 2014 NHFD report, this ranged from 100% to 35% (Royal College of Physicians, 2014). This was reported as an ongoing concern warranting local investigation in the 2017 report (Royal College of Physicians, 2017).

While the NHFD captures significant post-operative problems such as death, revision surgery, or large changes in functional mobility or independence, there may be inadequate information within the registry to understand outcomes which may contribute to patients' diminished quality of life without necessitating revision surgery.

The aims of this study were to quantify and compare the incidence of post-operative problems in patients with trochanteric hip fractures fixed with either SHS or IMN and, through comparison with problem-free controls, seek factors predictive of failure of fixation.

Patients and methods

Patients

Patients aged 65 years or more undergoing fixation of a trochanteric hip fracture at the Royal Surrey County Hospital, Guildford; the Royal United Hospital, Bath or Southmead Hospital, Bristol between 1 January 2013 and 31 December 2015 were eligible for inclusion. The study was registered as a service evaluation at the three participating sites. A matched case-control methodology was used, with patients matched on age (with a 5-year tolerance) and sex, with consecutive patients matched from the dataset. A matching ratio of 3:1 of controls to cases was targeted. The patients were identified from each site's National Hip Fracture Database dataset, which permits submitting centres to query their own patient data. In practical terms, this meant filtering the dataset by the fracture type and selecting all those recorded as trochanteric. Any patient already recorded on the NHFD as having required re-operation was added immediately to the "case" cohort.

Methods

For each patient in the dataset, local patient administration systems (PAS) were queried for orthopaedic outpatient episodes occurring after the date of discharge for the episode of care relating to the fracture. For these episodes, clinic letters were retrieved electronically and checked to ascertain if the appointment related to the hip fracture. Where the appointment was related, the patient became eligible for inclusion in the "case" cohort and the reason for referral, diagnosis and treatment was recorded. The problems were coded as: 1, mobility, falls or limp; 2, pain; 3, wound problems; 4, avascular necrosis, osteoarthritis or mal-union; 5, failure of fixation. For these patients, analysis of anteroposterior (AP) radiographs at presentation with hip fracture was performed to assign the fracture an AO classification of 31A1, A2 or A3 (OTA Classification, Outcomes and Database Committee 2018), and of intra-operative fluoroscopy views to determine tip-apex distance. Tip-apex distance was calculated using the method of Baumgaertner et al. (Baumgaertner et al., 1995). Missing radiographs were recorded as missing data, but the patient was not excluded from the study as the relatively low incidence of failure made it important that it was recorded. The NHFD was then used to determine the patient's American Society of Anesthesiologists grade, used in this study as a surrogate marker of level of health, pre-operative Abbreviated Mental Test Score (i.e. their cognitive capability) and mobility status. As different centres had been using different mobility ratings within the NHFD dataset, a composite “Best mobility” score was created, which could be derived from any combination of the “Pre-fracture mobility”, “Walking ability indoors”, “Walking ability outdoors”, “Aids to walk indoors” and “Aids to walk outdoors”. The best mobility score was rated as: 0, bed- or wheelchair-bound ; 1, mobile indoors but never goes outdoors; 2, goes outdoors with help; 3, mobile outdoors with 2 sticks or a frame; 4, mobile outdoors with a single stick; 5, freely mobile.

Statistical analysis

Statistical analysis was performed using SPSS version 24 (IBM, Armonk, NY). Comparison of categorical variables was by Chi-square testing, continuous by Mann-Whitney U and ordinal variables by independent samples Kruskal-Wallis test.

Binomial logistic regression was used to seek factors predictive of failure of fixation (i.e. membership of “case” cohort), with sex, operation type, AMTS, ASA grade, best mobility and AO classification entered as categorical variables and age and tip-apex distance as continuous variables.

Results

A total of 4010 patients were featured in the NHFD dataset for the three sites during the study period. Of these, 1260 patients had undergone fixation of extracapsular fractures. A cohort of 57 (4.5%) patients with problems were identified. The patients eligible for inclusion by site are shown in Figure 1.

All patients identified had some data available and so remained eligible for inclusion. Patient characteristics by cohort are summarized in Table 1. The cohorts were appropriately matched for age (79 years in the problem cohort and 81 in the problem-free cohort, $p=0.673$) and sex (82.5% female in the problem cohort and 83.1% female in the problem-free cohort, $p=0.916$). The surgical characteristics of the cohort are shown in Table 2.

The binomial logistic regression model was significant ($X^2=64.025$, $p < 0.001$) and explained 47.6% (Nagelkerke R^2) of the variance in incidence of post-operative problems. Sensitivity was 51.3%, specificity 94.7%, positive predictive value 74.1% and negative predictive value 86.7%. Two variables were predictive at the threshold for statistical significance – ASA grade ($p=0.001$) and tip-apex distance ($p=0.001$).

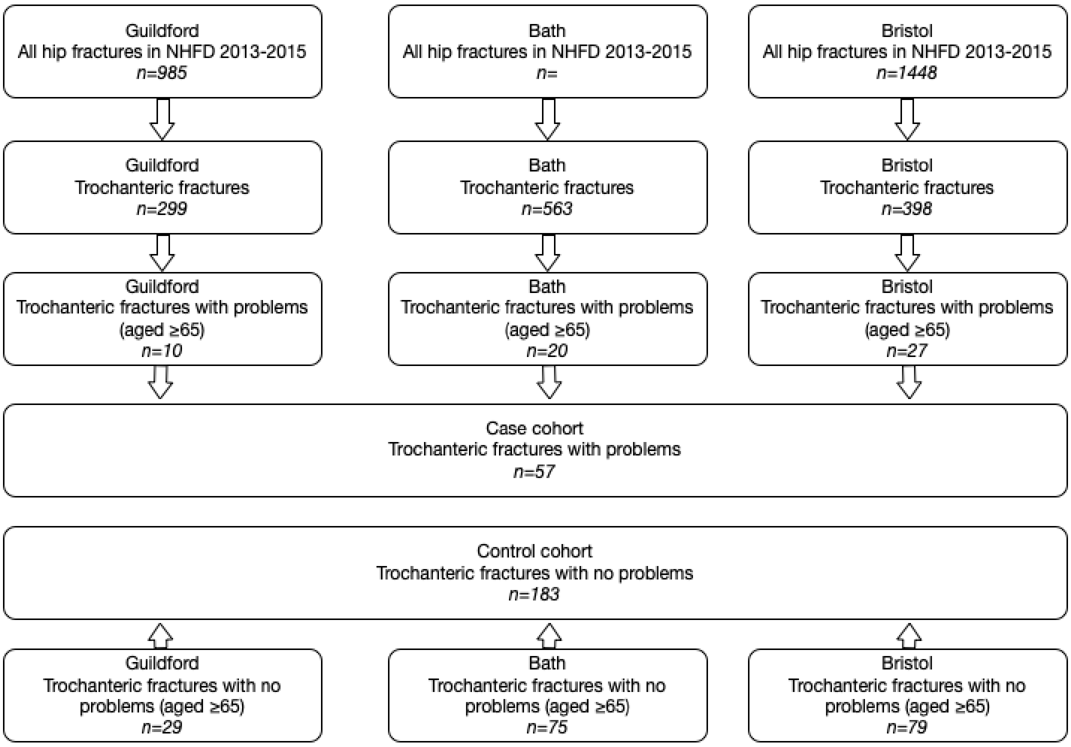

Figure 1 – Patient flow and inclusion diagram

		Case	Control	p value
Total		57	183	
Sex	Male	10	31	.916†
	Female	47	152	
Age		81.21 (65 – 98, SD 8.174)	81.62 (65 – 99, SD 71.21)	.673††
ASA grade	1	4	3	<0.0001 †††
	2	36	45	
	3	16	104	
	4	1	30	
	5	0	1	
AMTS	0	0	17	.003†††
	1	0	6	
	2	0	6	
	3	1	4	
	4	2	4	
	5	0	7	
	6	2	7	
	7	2	6	
	8	4	6	
	9	10	19	
	10	36	22	
Best mobility	Bed- or wheelchair-bound	2	7	.097†††
	Never goes outdoors	1	6	
	Mobile outside with help	2	22	
	Mobile with 2 sticks or frame	5	18	
	Mobile with single stick	8	25	
	Independently mobile	21	55	
Follow-up (months)		25.56 (0 – 47, SD 11.56)	22.34 (0 – 50, SD 14.39)	.143††

Table 1 – Patient characteristics by cohort

		Case	Control	p value
AO Classification	31A1	13	45	.146†††
	31A2	27	107	
	31A3	1	13	
	missing	16	18	
TAD (mm)		17.21 (3 – 28, SD 5.378)	15.32 (5 – 37, SD 5.047)	.005††
Operations	SHS	49	156	.501†
	IMN	8	22	
	missing	0	5	
Problems	Mobility, falls or limp	11		
	Pain	8		
	Wound problems	5		
	AVN, OA or mal-union	11		
	Failure of fixation	22		

Table 2 – Surgical characteristics by cohort

(† chi-square test, †† Mann-Whitney U test, ††† Independent samples Kruskal-Wallis test)

							95% CI for odds ratio	
Variable	B	S.E.	Wald	df	p value	Odds ratio	Lower bound	Upper bound
Age	0.045	0.033	1.888	1	0.169	1.046	0.981	1.116
Sex	-0.026	0.675	0.399	1	0.528	0.653	0.174	2.453
Best mobility			5.279	5	0.383			
	2.768	1.610	2.955	1	0.086	15.925	0.678	373.773
	0.356	1.636	0.047	1	0.828	1.427	0.058	35.238
	-1.064	0.985	1.169	1	0.280	0.345	0.050	2.375
	0.628	0.793	0.627	1	0.429	1.873	0.396	8.863
	0.399	0.705	0.320	1	0.572	1.490	0.374	5.939
AMTS			6.607	10	0.762			
	-18.895	9513.491	0.000	1	0.998	0.000	0.000	
	-18.767	27483.485	0.000	1	0.999	0.000	0.000	
	-19.780	13461.601	0.000	1	0.999	0.000	0.000	
	1.911	1.421	1.808	1	0.179	6.758	0.417	109.507
	2.536	1.604	2.500	1	0.114	12.624	0.545	292.485
	-19.014	15963.025	0.000	1	0.999	0.000	0.000	
	-17.403	28388.576	0.000	1	1.000	0.000	0.000	
	1.519	1.093	1.933	1	0.164	4.568	0.537	38.892
	-0.027	0.944	0.001	1	0.977	0.973	0.153	6.185
	1.151	0.714	2.600	1	0.107	3.162	0.780	12.812
AO Classification			2.275	2	0.321			
	-1.022	0.953	1.149	1	0.284	0.360	0.056	2.332
	-1.271	0.846	2.255	1	0.133	0.281	0.053	1.474
ASA Grade			16.820	3	0.001			
	23.722	7084.130	0.000	1	0.997	2.007E10	0.000	
	22.403	7084.130	0.000	1	0.997	5.366E9	0.000	
	20.070	7084.130	0.000	1	0.998	520203575	0.000	
Operation performed	0.622	0.773	0.646	1	0.421	1.862	0.409	8.476
Tip-apex distance	0.128	0.056	5.227	1	0.022	1.136	1.018	1.268
Constant	-27.494	7084.131	0.000	1	0.997	0.000		

Table 3 – Results of binomial logistic regression

Discussion

This study helps bridge the gap in understanding of incidence of problems after fixation of hip fractures which exists between those complications reported to and immediately identifiable from the National Hip Fracture Database, and those identified in complex data linkage studies.

The incidence of problems was low, in the region of 5% for all types of problem and 2% for failure of fixation. This is in keeping with previous work by this team and other contemporaneously published rates for the UK (Page et al. 2016; Bretherton & Parker 2016). This study builds on that work by exploring more patient characteristics, focusing less on temporal trends in usage of different fixation devices and it adds inferential statistical analysis to the information gained. The data capture and categorization of problems was purposely crude in order to reflect what was recorded in narrative form in clinical letters. Thematic grouping was, therefore, a pragmatic manner of reporting these problems.

An increasing ASA grade was predictive of problems with fixation. This is unsurprising if one considers it a surrogate marker of overall health status where an increasing grade represents poorer health. Given the outcome measure was any form of problem, rather than failure of fixation *per se*, this predictor may reflect more the impact of worsened health status on a patient's overall ability to recover from the injury. The link between co-morbidity and adverse outcomes has long been established, Roche et al. reported in 2005 that co-morbidity was predictive of both complications and death after hip fracture surgery, using an a priori list of complications of interest (Roche et al. 2005). Donegan et al. further demonstrated similar findings, while Bjorgul et al. evaluated the validity of the ASA grade specifically for meaningfully measuring co-morbidity in this patient population (Donegan et al. 2010; Bjorgul et al. 2010). Härstedt et al. used both a pre-determined list of co-morbidities and the ASA grade, finding both to be independently predictive of re-admission or death within six months of hip fracture surgery (Härstedt et al. 2015). Having established both the validity of the use of this score and the face validity of our results in the context of existing evidence, the novel aspect we wish to highlight is that health status is also predictive of other problems in our population, which may simply represent a limp or pain.

This area undoubtedly requires further exploration, but our finding should broaden our peri-operative thought process as surgeons to encompass the potential additional rehabilitation requirements when we recognize a patient's co-morbidity, rather than simply considering intra-operative risk or peri-operative complications or death.

The tip-apex distance featuring significantly in the model was anticipated, given its already established status as an independent predictor of cut-out of the screw from the femoral head (Baumgaertner et al. 1995). This has been replicated numerous times in other studies including the author's own follow-up study (Baumgaertner & Solberg 1997; Bojan et al. 2013). There remains the argument that the quality of reduction is as important as the TAD; while this is challenging to agree a consensus around and to measure in the research context, especially in the absence of standardized post-operative radiographs, a more detailed study of predictors of failure is likely to need to include this as a biomechanical variable. The current common approaches to this, however, such as anatomical *versus* non-anatomical when considering potentially highly comminuted fracture patterns (Bojan et al. 2013) must evolve to a biomechanically and clinically meaningful one.

The absence of best mobility as a predictor of outcome may speak more to its absence from the data of 69 patients than insignificance, and so we would counsel against inferring lack of importance of this when considering the patient holistically. By the same token, a large amount of missing data in the AO classification field adds similar equivocation.

The decision to use matched cohorts was intended to reduce the heterogeneity of the samples, by ensuring age and sex were broadly similarly distributed between groups. The pool of potential participants would probably not support sufficient combinations to match any more variables. It could be argued that an unmatched cohort would probably not have had a significantly different median age or different female to male patient ratio and it may be that this matching strategy actually reduced the power of the study. Future work in this area may be better served by simply describing the populations encountered, rather than matching them.

The assumption that patients experiencing problems with their fixation would return to their treating hospital is also one open to question. A more robust methodology would have been to access population-level data; Nedza et al. were able to report Emergency Department attendances in arthroplasty patients, including those undergoing total hip replacement for fracture, by using a state-wide billing system to capture re-presentation anywhere in the state (Nedza et al., 2017). This type of methodology relies on high-quality centralised data, which in the UK may be obtained through Hospital Episode Statistics (HES) information. Such investigation was, however, beyond the resource constraints of this project. The argument that patients will seek help from or be referred back to their treating centre is one which must be counter-balanced with the possibility of patients explicitly seeking a second or different opinion from a different centre due to discontent with outcomes. This remains a perennial problem in retrospective research and is well-described in the literature, without a robust solution apparent (Morris et al., 2011; Zmistowski et al., 2013).

Overall, we have demonstrated that the fixation of hip fractures remains an imperfect science, that adhering to technical good practice remains important regardless of the device used, and that patient pre-injury health state remains more predictive of problems after hip fracture than the device used. Further, we have demonstrated the existence of a population of patients, who are evident at an individual patient level but who are not immediately evident from large national datasets. This in turn reflects the importance of understanding what a dataset does and does not capture, as well as the potential difference in impact of these outcomes between individuals and populations.

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